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Pace

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[54] **RAILROAD CROSSING TRAFFIC WARNING SYSTEM APPARATUS AND METHOD THEREFORE**

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[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **09/056,201**

[22] Filed: **Apr. 6, 1998**

Related U.S. Application Data

[63] Continuation of application No. 08/710,147, Sep. 16, 1996, Pat. No. 5,735,492, which is a continuation-in-part of application No. 08/601,902, Feb. 15, 1996, which is a continuation-in-part of application No. 07/650,303, Feb. 4, 1991, abandoned

[60] Provisional application No. 60/009,857, Jan. 16, 1996.

[51] **Int. Cl.**[6] **B61L 29/00**

[52] **U.S. Cl.** ...... **246/293**; 246/294; 246/125; 246/167 A

[58] **Field of Search** ...... 246/294–296, 246/112, 113, 293, 114 R, 114 A, 167 A, 217, 473 R, 473.1, 473.2, 488, 125, 126; 340/901, 902, 905, 941

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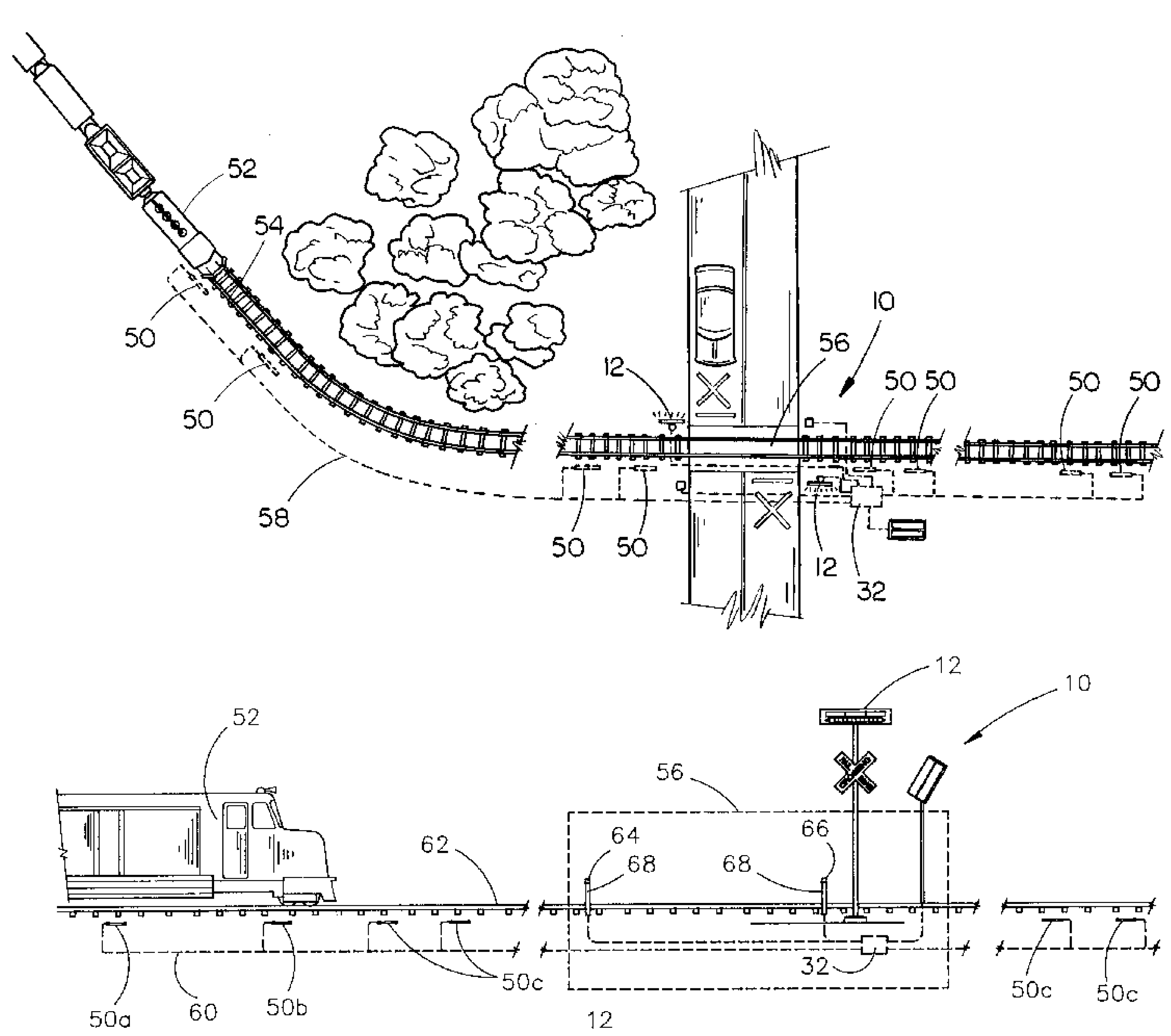
[57] **ABSTRACT**

A railroad crossing traffic warning system for alerting a motorist approaching a railroad crossing to the presence of an oncoming train. The system comprises a series of magnetometer sensor probes buried in the right-of way adjacent to a railroad track at predetermined distances from the railroad crossing. These sensors provide a signal to a controller unit when the presence of a train is sensed. The controller unit first determines the speed at which the oncoming train is traveling and the time it will take for the train to reach the crossing and then activates an improved warning apparatus at a predetermined amount of time before the train reaches the crossing. The improved warning apparatus comprises an X-shaped railroad crossing warning sign or "crossbuck" having a plurality of light emitting diodes ("LED") or the like mounted on the across the center thereof, a plurality of strobe lights, and a train direction indicator comprising a plurality of lamps which are lighted sequentially to indicate the direction in which the oncoming train is traveling. The system may be powered by a rechargeable battery which may be recharged by a solar panel array allowing the system to be utilized at crossings located in rural areas where a source of AC electrical power is not readily available.

20 Claims, 9 Drawing Sheets



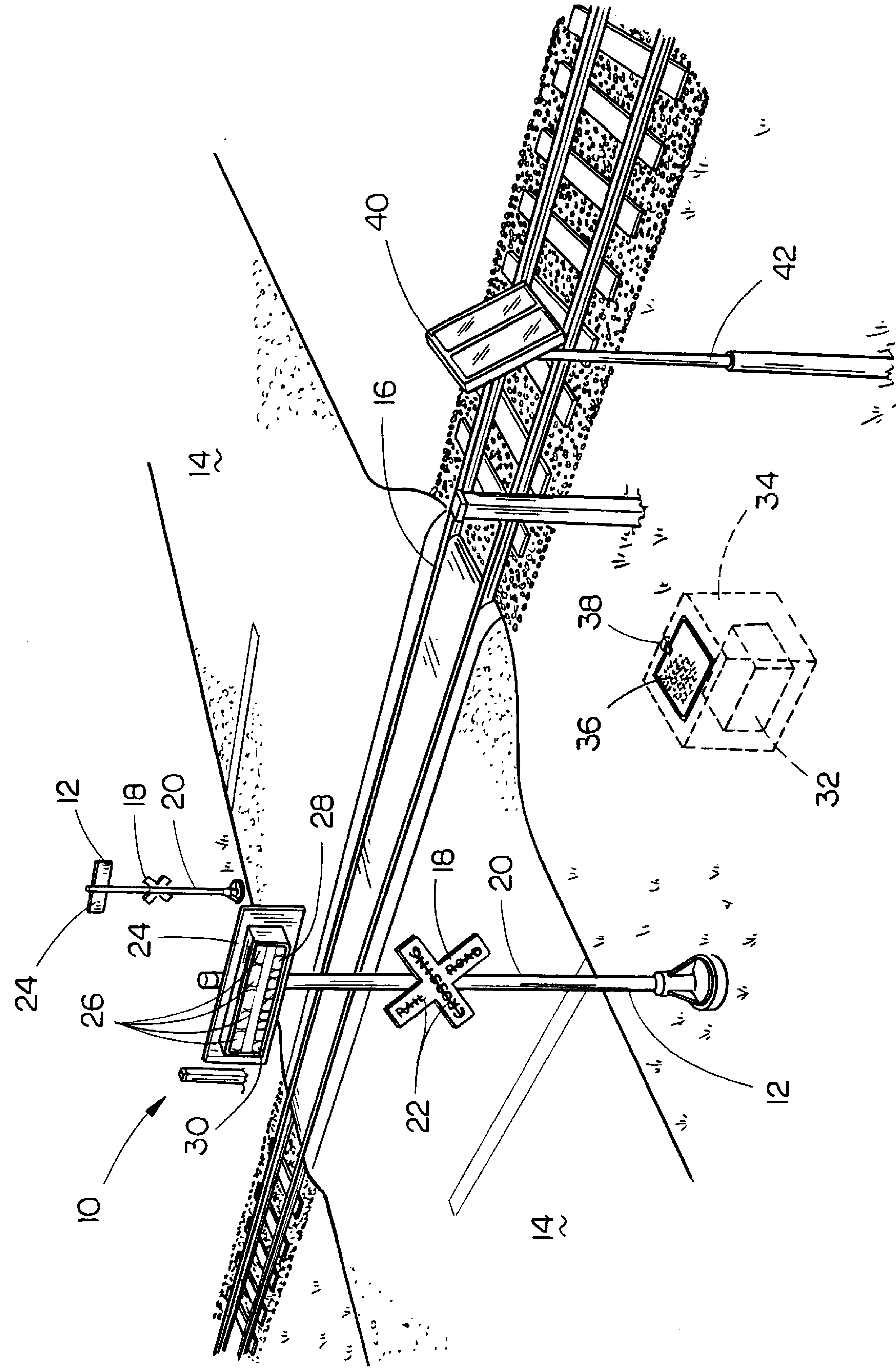


FIG. 1

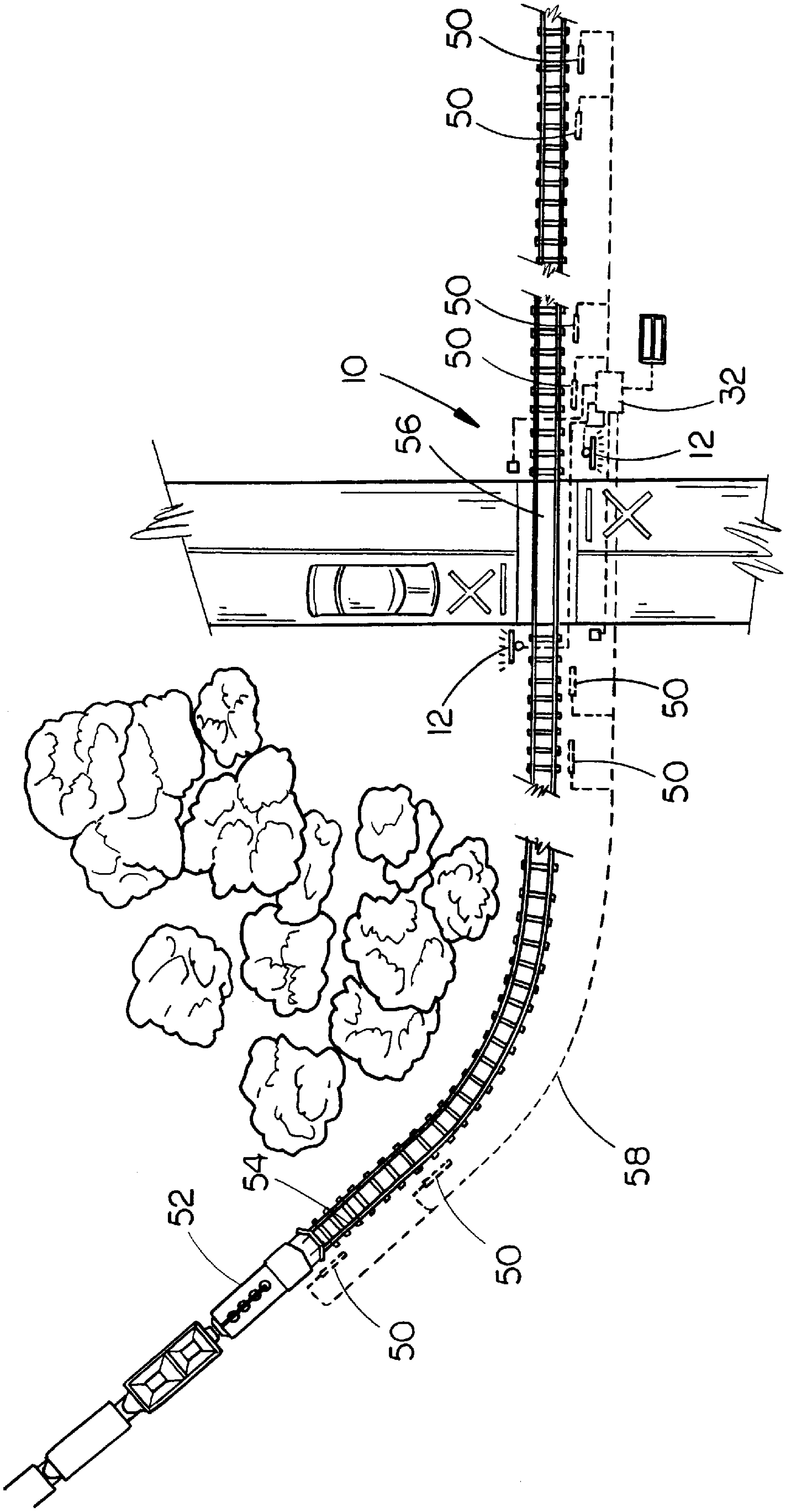
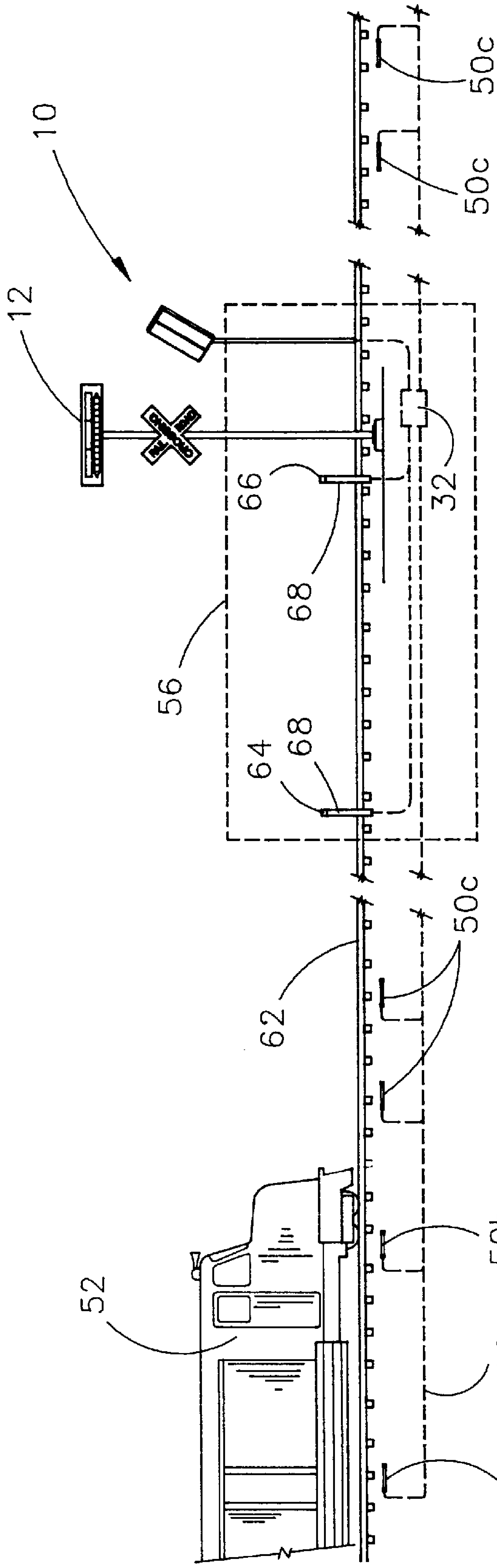
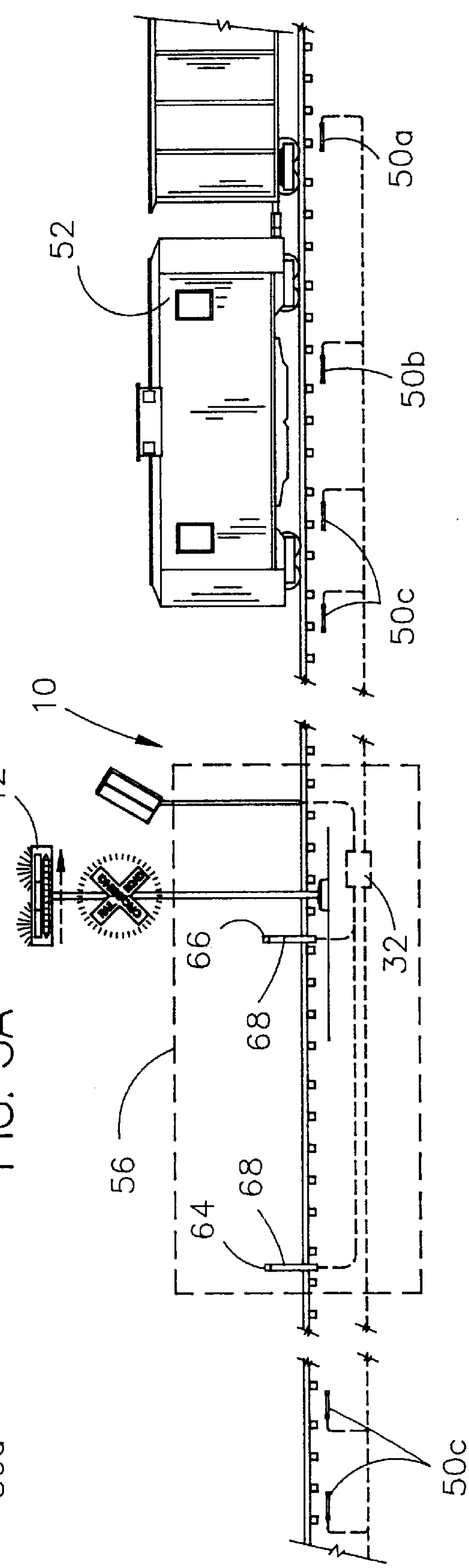


FIG. 2



10
12
66
68
32
56
64
68
50c
50c
62
50c
52
50b
60
50a

FIG. 3A



52
50a
50b
50c
10
12
66
68
32
56
64
68
50c

FIG. 3B

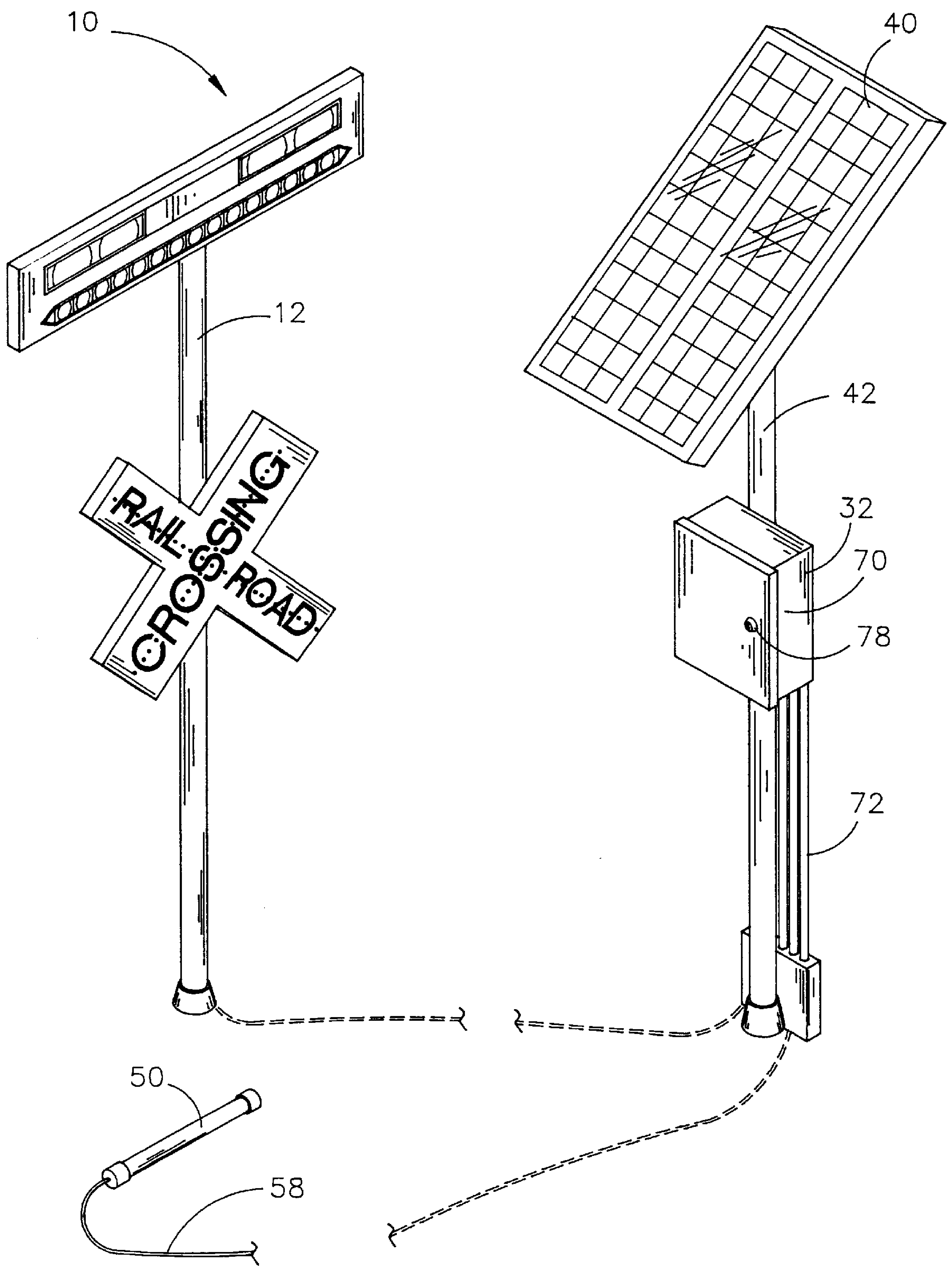


FIG. 4

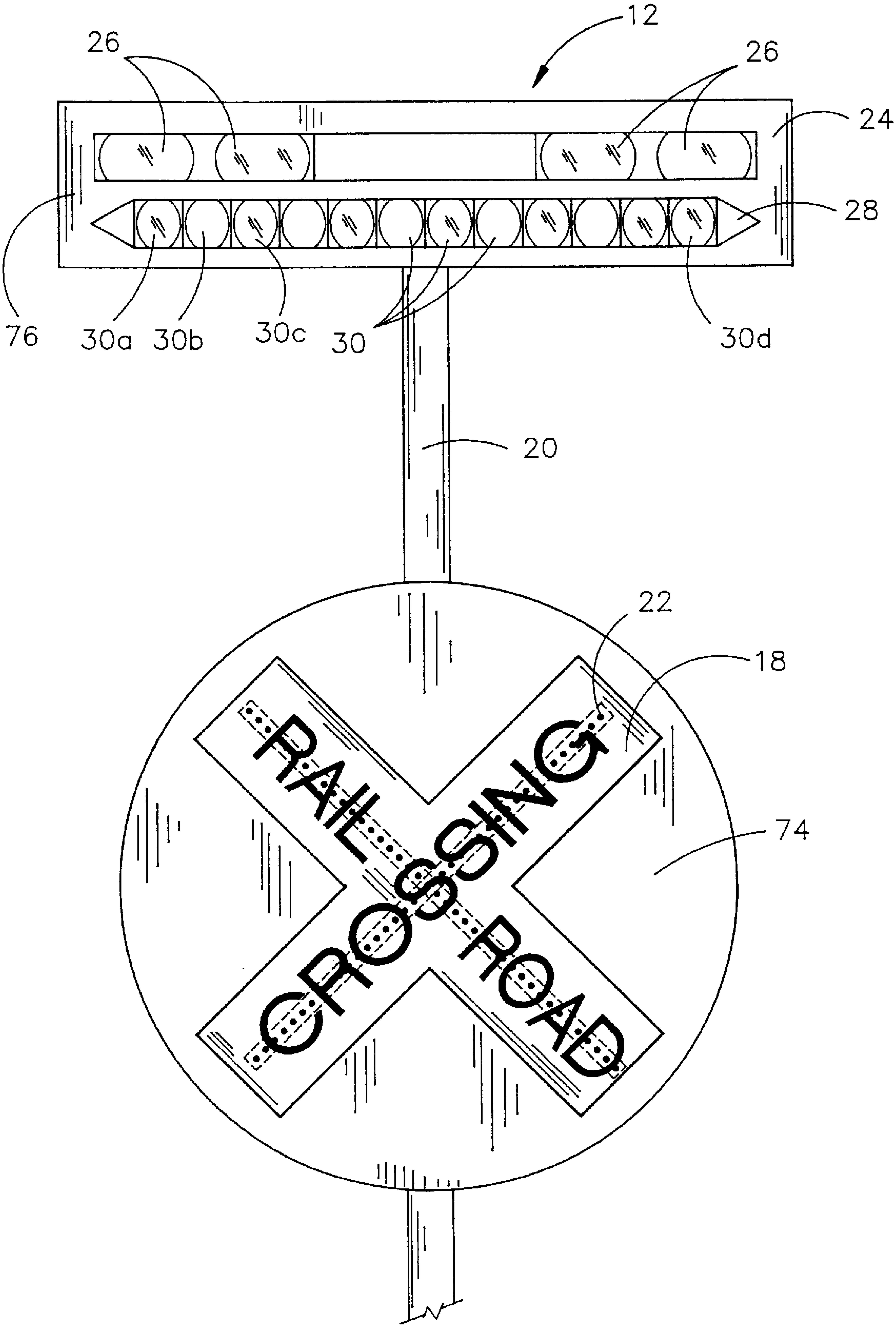

12
26
26
24
28
76
30a
30b
30c
30
30d
20
22
18
RAIL
ROAD
CROSSING
74

FIG. 5

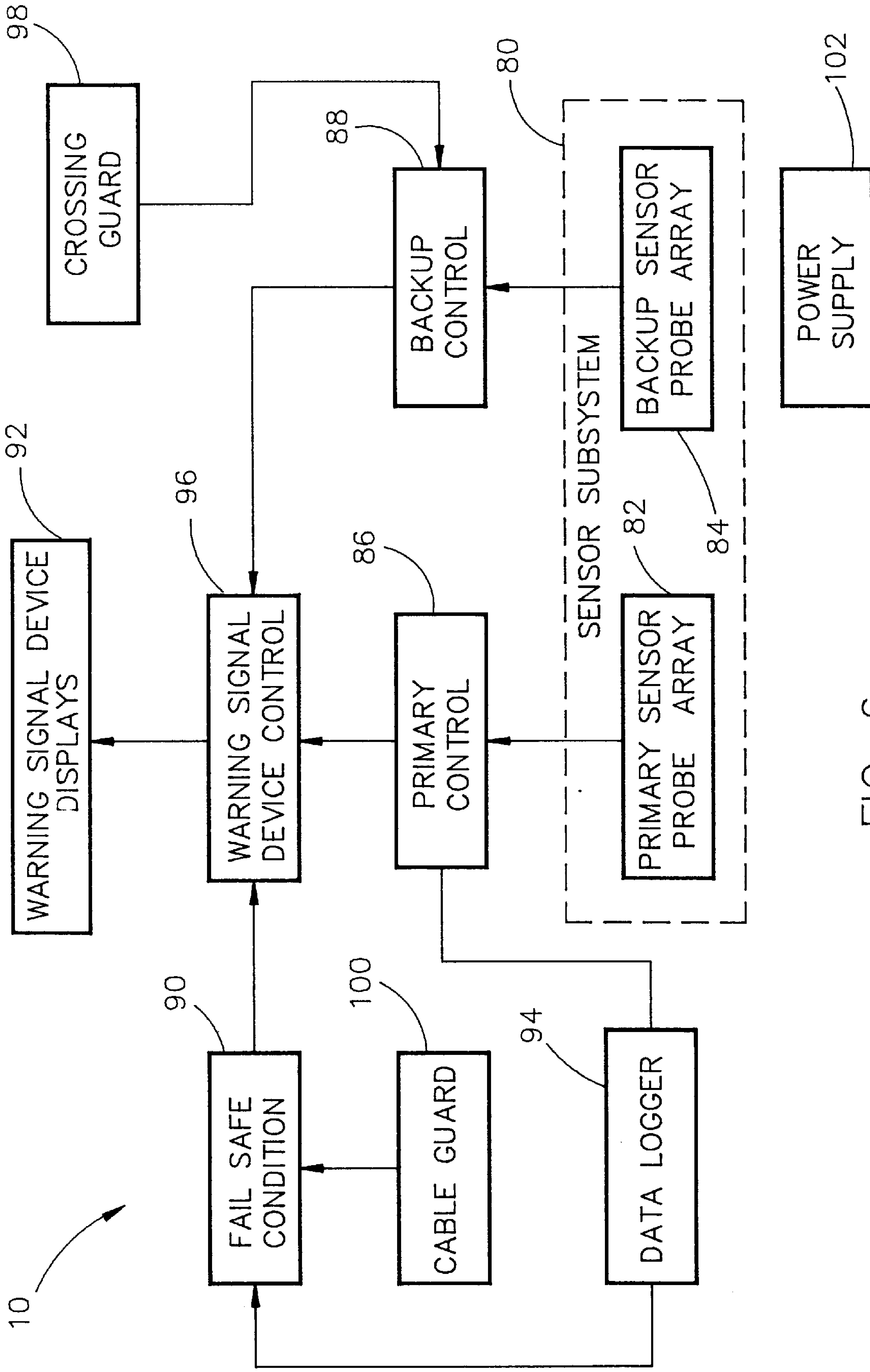

CROSSING GUARD
BACKUP CONTROL
SENSOR SUBSYSTEM
BACKUP SENSOR PROBE ARRAY
POWER SUPPLY
WARNING SIGNAL DEVICE DISPLAYS
WARNING SIGNAL DEVICE CONTROL
PRIMARY CONTROL
PRIMARY SENSOR PROBE ARRAY
FAIL SAFE CONDITION
CABLE GUARD
DATA LOGGER
10
80
82
84
86
88
90
92
94
96
98
100
102

FIG. 6

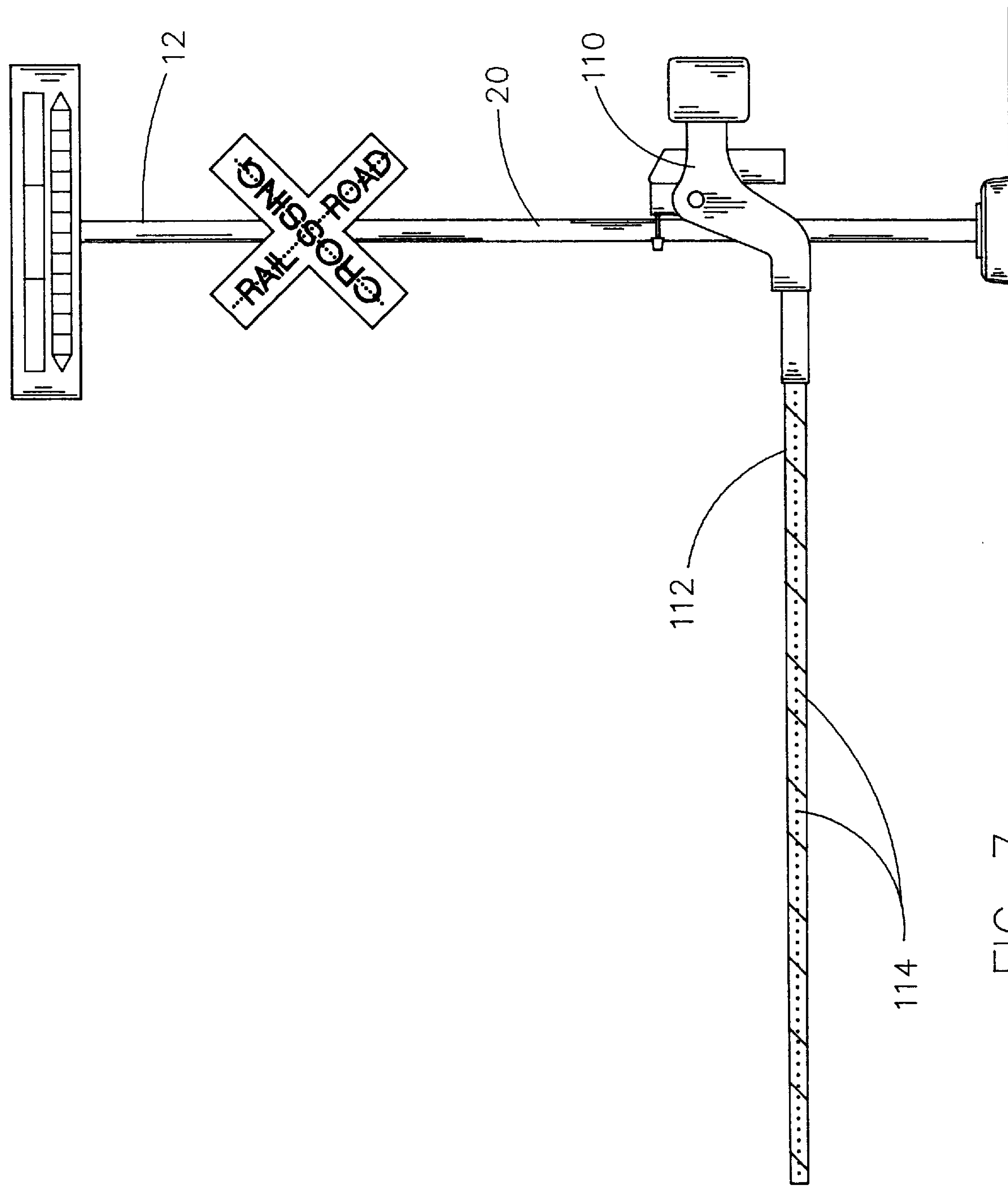


FIG. 7

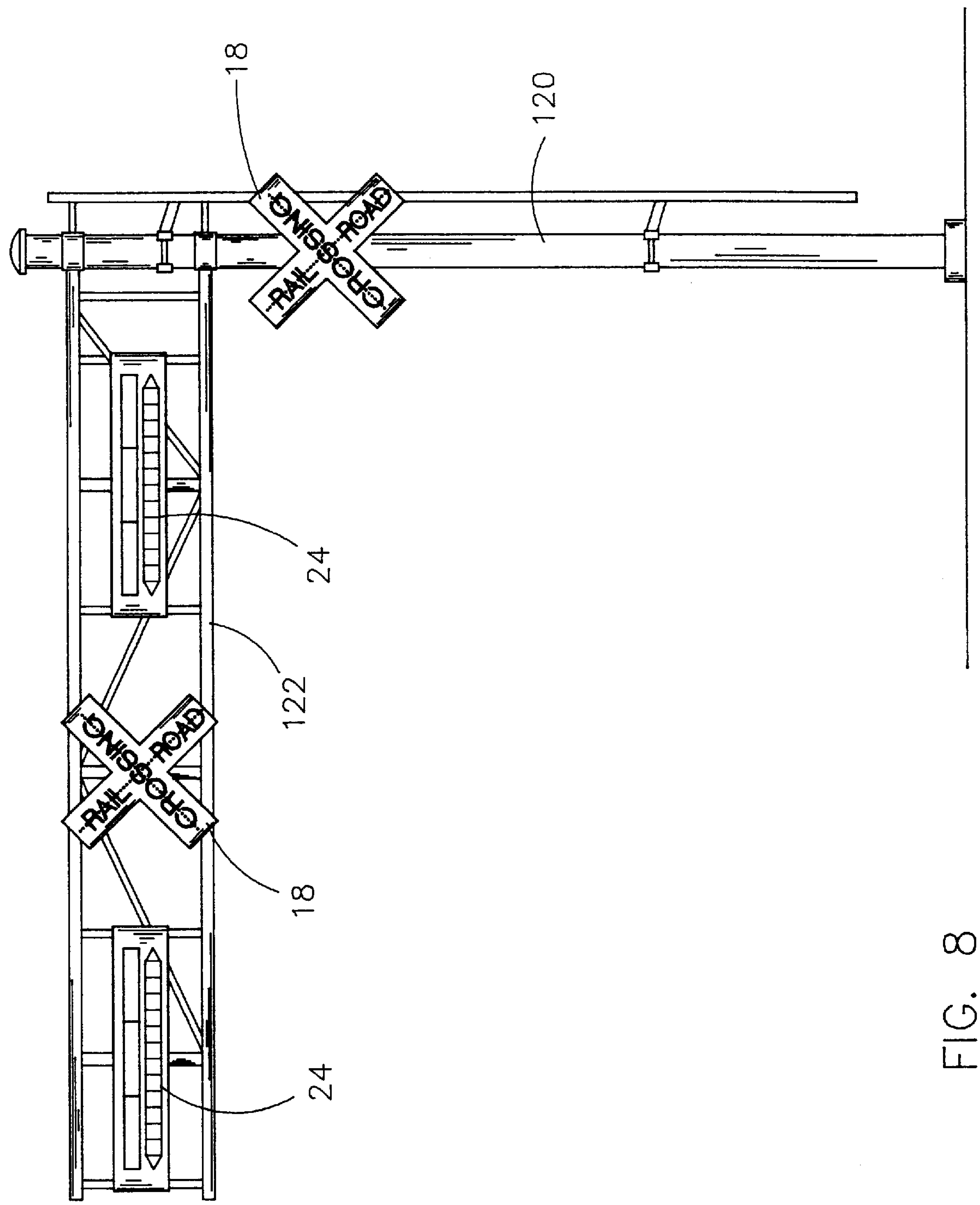


FIG. 8

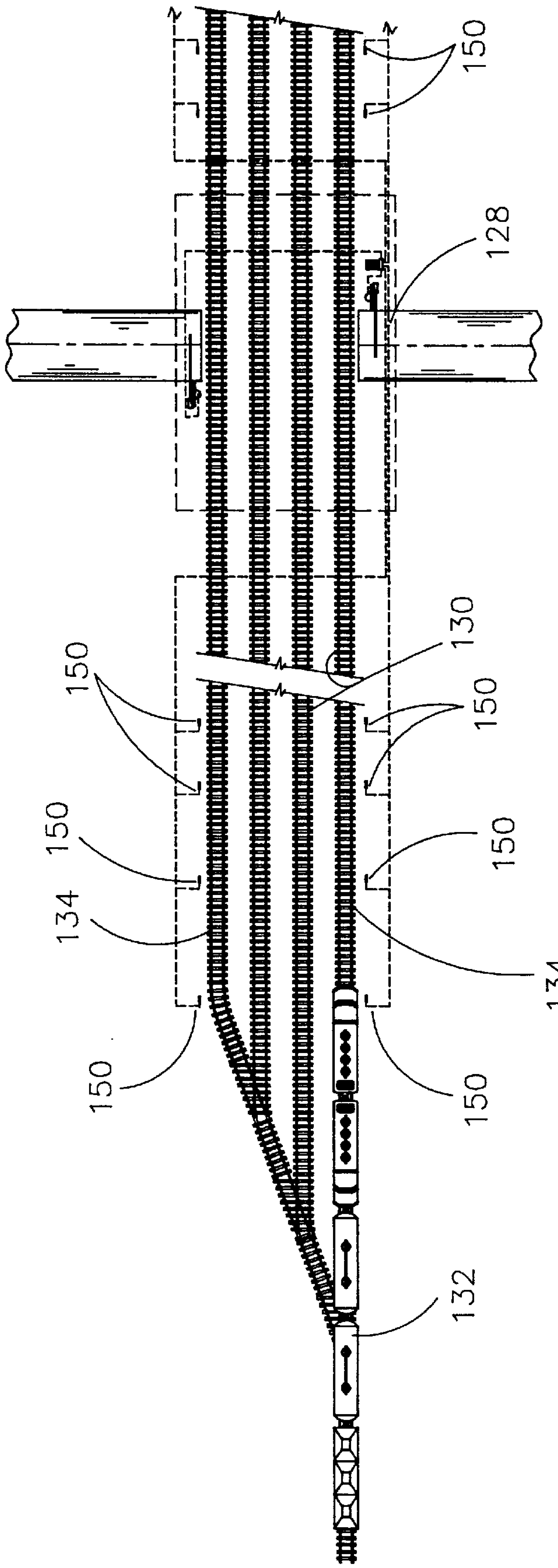


FIG. 9

RAILROAD CROSSING TRAFFIC WARNING SYSTEM APPARATUS AND METHOD THEREFORE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. application Ser. No. 08/710,147 filed Sep. 16, 1996, now U.S. Pat. No. 5,735,492, issued Apr. 7, 1998, which is a continuation-in-part of U.S. application Ser. No. 08/601,902 filed Feb. 15, 1996, which is a continuation-in-part of U.S. application Ser. No. 07/650,303 filed Feb. 4, 1991 (abandoned). Said application Ser. No. 08/601,902 claims the benefit under 35 U.S.C. § 119 of U.S. Provisional Application Ser. No. 60/009,857 filed Jan. 12, 1996.

The entire disclosure of U.S. application Ser. No. 08/710,147, filed Sep. 16, 1996, is considered to be part of the disclosure of the present application and is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present invention relates generally to traffic warning systems and more particularly to a railroad crossing traffic warning system for alerting motorists approaching a railroad grade crossing to the presence of an oncoming railroad train.

BACKGROUND OF THE INVENTION

There are over 223,000 railroad grade crossings in the United States alone. Most of these crossings, especially those in rural areas, have only warning signs to alert motorists to the danger posed by an approaching train. Typical of railroad grade crossing warning signs is the familiar X-shaped "RAILROAD CROSSING" sign or "crossbuck." Warning signs, however, only alert motorists to the presence of a railroad crossing and do not alert them to the presence of an oncoming train. Often, a motorist may fail to see an approaching train because he was distracted or because his view of the train was obstructed by environmental conditions or darkness. Consequently, collisions between trains and automobiles at railroad crossings account for thousands of accidents each year, many of which result in extensive property damage and serious injury or death to motorists.

Known to the art are active railroad crossing warning systems utilizing the railroad tracks themselves to detect an approaching train and activate warning signal apparatus such as flashing lights and bells. These systems warn motorists when a train is detected at a predetermined distance from the crossing. However, present active warning systems do no take into account the speed of the train and thus make no allowance for the time it will take the train to reach the crossing. For example, a fast moving train may reach the crossing in only a few seconds after it is detected, while a slow moving train may fail to reach the crossing until several minutes have passed. Motorists may become impatient waiting for slow moving trains to reach the crossing. Consequently, some motorists may begin to ignore the warnings and attempt to cross the tracks possibly causing an accident should a fast moving train be encountered. Further, installation of current active warning systems may require the insulation and resetting of great lengths of track. Additionally, these systems may require the installation of expensive high voltage transformers, relays, and batteries for backup systems. Unfortunately, many rural crossings are not conducive to the installation of active warning systems

that requires AC electrical power and extensive grade preparation. Consequently, these crossings usually remain inadequately protected. High speed rail corridors being proposed across the United States will only exacerbate this problem. These corridors will require improved crossing warning systems to properly secure the safety of both passengers and motorists.

OBJECTS OF THE INVENTION

Therefore, it is an object of the present invention to provide an improved railroad crossing warning system for warning a motorist, pedestrian, bystander, or the like to the presence of an approaching railroad train.

It is another object of the present invention to provide an improved railroad crossing warning system suitable for operation at remote or rural railroad grade crossings where a source of AC electrical power may not be available.

It is a further object of the invention to provide an improved railroad crossing warning system that may be easily installed at existing railroad crossings without removing, replacing or interfering with the existing railroad track.

It is yet another object of the invention to provide an railroad crossing warning system having improved warning signal devices, signs and the like.

It is still another object of the present invention to provide an improved railroad crossing system wherein the warning signal device is activated at a predetermined interval of time before the train reaches the railroad crossing.

Another object of the present invention is to provide an improved railroad crossing warning system having means to detect a stopped train at a crossing so that activation of the warning signal device or sign may be continued.

It is an object of the present invention to provide a means of collecting and recording data regarding the operation of the warning system and information about the trains passing the crossing.

A further object of the present invention is to provide an improved railroad crossing system comprising a primary system and redundant backup and fail-safe systems for added reliability and safety.

It is yet a further object of the present invention to provide an improved railroad crossing warning system wherein the components are reliable, easily maintained, and protected against vandalism.

SUMMARY OF THE INVENTION

In accordance with these objects, the present invention provides a railroad crossing traffic warning system for alerting a motorist approaching a railroad crossing to the presence of an oncoming train. As used herein, "motorist" is intended to refer not only to operators and passengers of motor vehicles, but also to pedestrians, cyclists, bystander, and the like. Sensors buried adjacent to the train rails at predetermined distances from the railroad crossing detect the presence of an approaching train. A control unit, processing signals received from these sensors, determines the speed at which the train is traveling and the time required for the train to reach the crossing. At a predetermined time before the train reaches the crossing, the control unit activates warning apparatus to alert motorists to the presence of the oncoming train. The motorists may then take cautionary or evasive action.

The system also includes improved warning apparatus. The warning apparatus comprises an X-shaped railroad crossing warning sign or "crossbuck" having reflectors, reflecting paint, or the like for reflecting the headlights of an automobile, a plurality of strobe lights to enhance the motorist's awareness of the approaching train and a train direction indicator. The crossbuck may include a plurality of light emitting diodes ("LED") or the like mounted on the across the center of the crossbuck in an X-shape. The train direction indicator comprises a plurality of lamps placed adjacent to each other in a line. These lamps are lighted sequentially to indicate the direction in which the oncoming train is traveling. Further, the warning apparatus may further include an audible warning means such as a siren horn or bell to provide an audible output signal.

Crossing guard apparatus may also be provided to detect the presence of a stopped train in the railroad crossing so that activation of the warning apparatus may be continued until the train moves from the crossing. The crossing guard includes an infrared transmitter and a receiver mounted diagonally across the crossing. The transmitter transmits an infrared beam of light across the crossing to the receiver. If a train is present in the crossing the beam is interrupted and a signal is sent to the control unit.

The system may be powered by a rechargeable battery. This battery may be recharged by a solar panel array allowing the system to be deployed at crossings located in rural areas where a source of AC electrical power is not readily available.

BRIEF DESCRIPTION OF THE DRAWINGS

The numerous objects and advantages of the present invention may be better understood by those skilled in the art by reference to the accompanying figures in which:

FIG. **1** is a pictorial view of a typical single track grade crossing employing a railroad crossing warning system according to an exemplary embodiment of the present invention;

FIG. **2** is a top plan view of an area surrounding a typical grade crossing, as illustrated in FIG. **1**, depicting the placement of the warning system's components along the track;

FIG. **3**A is an elevational view of the embodiment of the invention shown in FIGS. **1** and **2** illustrating the operation thereof before an oncoming railroad train reaches the crossing;

FIG. **3**B is an elevational view of the embodiment of the invention shown in FIGS. **1** and **2** illustrating the operation thereof after passage of the train;

FIG. **4** is a perspective view of the basic components of the warning system according to an exemplary embodiment of the present invention;

FIG. **5** is a front elevational view depicting a warning signal device according to an exemplary embodiment of the invention;

FIG. **6** is a schematic diagram of the warning system illustrating the operational features thereof;

FIG. **7** is a front elevational view depicting a warning signal device according to an exemplary embodiment of the present invention employing a crossing gate; and

FIG. **8** is a front elevational view of a warning signal device mounted on a cantilever assembly according to alternative embodiment of the present invention.

FIG. **9** illustrates the use of the present invention in a railroad crossing having multiple railroad tracks, such as in an industrial area or near a freight yard.

DETAILED DESCRIPTION OF AN EXEMPLARY EMBODIMENT

FIG. **1** depicts a typical single track grade crossing employing a railroad crossing warning system **10** according

to an exemplary embodiment of the present invention. The warning system **10** preferably comprises several components which operate separately of the railroad's track, equipment, or systems to provide means of actively warning a motorist, pedestrian, or the like ("motorist") approaching the crossing of the presence of an oncoming train. Warning signal devices **12** may be erected adjacent to a road or highway **14** on either side of the crossing **16**. These devices **12** are preferably positioned facing oncoming traffic so as to be clearly visible to a motorist approaching the crossing on the road or highway **14**. Preferably, each device **12** comprises a standard X-shaped railroad crossing warning sign or "crossbuck" **18** having reflectors, reflective paint, or the like for reflecting the lights of an approaching automobile. The crossbuck **18** may be mounted on a post, pole, mast or like supporting means **20** which is anchored in the ground next to the crossing. Visibility of the crossbuck **18** may be further enhanced by a plurality of light emitting diodes ("LED"s) **22** mounted across the center of the crossbuck **18** such that they form an X-shape. These LEDs **22** may be animated, i.e. made to flash so as to attract the motorists attention. A strobe light/train direction advisory sign **24** may be mounted above the crossbuck **18** on the mast **20**. This sign **24** may include a plurality of strobe lights **26** which function to alert inattentive motorists to the presence of the approaching train. A train direction indicator **28** may also be provided comprising a plurality of lamps **30** placed adjacent to each other in a straight line. Upon detection of the presence of an approaching train by the system, these lamps **30** may be lighted sequentially in a repetitious manner to indicate the direction in which the oncoming train is traveling. Embodiments of the warning signal device **12** may further include an audible warning means such as a siren horn or bell (not shown) to provide an audible warning to the motorist.

A control unit **32** may activate the warning signal devices **12** when an approaching train is detected. The control unit **32** may be housed in a waterproof underground vault **34** located near the railroad grade crossing. The vault **34** may include a steel access door **36** secured by a locking device **38** such as a hasp to receive a padlock or the like. The buried vault **34** may provide physical security for the control unit **32** protect the control unit's electronics from the extreme temperature changes that could be experienced were the control unit **32** to be located in an above ground enclosure which had no heating and air conditioning. Preferably, the vault **34** may be grounded to provide electrostatic shielding to the electronic components contained therein.

The system **10** is preferably powered by rechargeable batteries (not shown). The batteries may be housed within the vault **34** with the control unit **32**. Recharging of the batteries may be accomplished by means of a solar panel array **40** mounted on a pole, or post **42** near the crossing. Use of solar panels **40** to recharge the system batteries is desirable when the system **10** is to be deployed at crossings located in rural areas where a source of electrical power is not readily available. The crossbuck **12**, strobe light/train direction advisory sign **24**, and solar panels **40** may have transparent coverings comprising ½ inch thick LEXAN® or the like to prevent damage due to the environment or vandalism.

As illustrated in FIG. **2**, the system **10** preferably includes a series of remote sensors probes **50** which are capable of detecting the presence of a train **52**. The sensor probes **50** may be positioned adjacent to the train rails **54** at predetermined distances from the railroad crossing **56**. Preferably, each sensor **50** comprises a magnetometer enclosed in a sealed housing assembly which may be buried in the right-of-way to the railroad tracks to prevent vandalism. The magnetometers produce a signal in response to local disturbances of an electromagnetic field, such as the disturbance of the magnetic field of the earth caused by the passing of a large metallic object such as a train. The sensor probes **50** may be interconnected with electronic circuitry in the control unit **32** which produces a binary (on or off) signal when the presence of a train is detected. Shielded, rodent proof, multi-conductor sealed cables **58**, which may also be buried in the right-of way, may interconnect the remote sensor probes **50** to the control unit **32**. These cables **58** may be further protected by electronic circuitry within the control unit **32** which monitor the integrity of a closed loop circuit in the buried cable. In the event that a cable **58** is cut or damaged, the control unit **32** will sense a break in the closed loop circuit and place the system in a fail safe mode of operation which automatically activates the warning signal devices **12**.

FIGS. **3**A and **3**B illustrate operation of the system **10** to detect an approaching train **52** and activate warning signal devices **12** located at the crossing **56**. The railroad crossing warning system **10** preferably comprises a primary train detection subsystem and a secondary or backup train detection subsystem. The primary train detection subsystem may include two speed traps **60** each comprising two sensor probes **50***a* & **50***b* positioned on either side of the grade crossing **56** along the track **62** at a predetermined distance from each other. The sensor probes **50***a* & **50***b* are preferably located at a sufficient distance from the grade crossing **56** to permit the system **10** to activate the warning signal devices **12** at a predetermined interval of time before the arrival of the train **52** regardless of the train's speed. The sensor probes **50***a* & **50***b* may be buried in the earth in the right-of-way adjacent to the track **62** to prevent damage or vandalism. As a train **52** approaches the crossing **56**, it passes a first primary sensor probe **50***a* positioned at a first predetermined distance from the crossing **56** and is detected. The first primary sensor probe **50***a* provides a train detection signal to the control unit **32** which is preferably located in the underground vault near the crossing **56**. As the train **52** continues toward the crossing **56**, it reaches a second primary sensor probe **50***b* positioned at a second predetermined distance from the crossing **56** such that its distance from the first primary sensor probe **50***a* is known. The second primary sensor probe **50***b* also detects the presence of the train **52** and sends a second train detection signal to the control unit **32**. Electronic circuitry, preferably including a microprocessor, in the control unit **32** measures the time interval between receipt of the first train detection signal and receipt of the second train detection signal and using the known distance between the first and second primary sensor probes **50***a* & **50***b* calculates the speed of the train **52** and the time it will take the train **52** to reach the crossing **56**.

A secondary or backup subsystem may also be provided should the primary system fail to properly detect the approaching train. Like the primary subsystem, the backup subsystem may include magnetometer sensor probes **50***c* buried in the earth in the right-of-way on either side of the grade crossing **56**. Each backup sensor probe **50***c* is preferably positioned at a predetermined distance from the crossing **56** along the track **62**. The backup sensor probes **50***c*, however, are placed between the second primary subsystem sensor probe **50***b* and the grade crossing **56** at a sufficient distance from the crossing to permit activation of the warning signal devices **12** before the train **52** reaches the crossing. During normal operation, the primary subsystem, upon proper detection of a train **52** by both the first and second primary sensor probes **50***a* & **50***b*, disables operation of the backup system. If, however, the primary subsystem malfunctions or the train **52** is not detected by both of the primary sensor probes **50***a* & **50***b*, the backup subsystem provides means of activating the warning signal devices **12** before the train **52** reaches the crossing **56**. For example, the approaching train **52** is detected by the first primary sensor probe **50***a*. However, due to malfunction, the second primary sensor probe **50***b* fails to detect the train **52**. The primary subsystem cannot determine the speed of the approaching train **52** in order to determine the appropriate time in which to activate the warning signal devices **12**. Electronic circuitry, preferably including a microprocessor, within the control unit **32** does not disable the backup subsystem. As the train **52** continues toward the crossing **56**, it reaches the first of the backup sensor probes **50***c* and is detected. The backup sensor probe **50***c* provides a signal to the control unit **32** which may immediately activate the warning signal devices **12**.

A crossing guard subsystem may be provided comprising apparatus capable of detecting the presence of a train **52** either moving or stopped across the grade crossing **56**. The crossing guard subsystem preferably allows the warning system to continue activation of the warning signal devices **12** until the train **52** clears the crossing. The crossing guard subsystem is preferably enabled when either the primary or backup subsystems detect the presence of a train **52** approaching the crossing **56**. An infrared transmitter **64** and receiver **66** may be mounted on posts **68** located near the crossing **56** on either side of the track **62**. Preferably, these posts **68** are positioned so that the transmitter **64** may transmit an infrared beam of light diagonally across the crossing **56** to the receiver **66**. If a train **52** is present in the crossing **56** the infrared beam is interrupted and does not reach the receiver **66**. The receiver **66** then may provide a signal to the control unit **32** indicating the presence of a train **52** in the crossing **56**. After the train **52** has passed the crossing, the receiver **66** may provide a signal to the control unit **32** indicating that the end of the train **52** has cleared the crossing **56**. The control unit **32** may then deactivate the warning signal devices **12** immediately or after a predetermined interval of time, for example 10 seconds. When no train has been detected by the warning system's primary or backup subsystems, the crossing guard subsystem is preferably disabled by the control unit **32** to avoid false activation of the warning signal devices **12** by an automobile or truck passing through the crossing.

As illustrated in FIG. **4**, the warning system **10** may include several standard components which may be easily assembled together when deployed at a remote site such as a grade crossing located in a rural area. The control unit **32** may be mounted in an above-ground enclosure **70**. This enclosure **70** may be made of steel and have a locking mechanism **78** to prevent vandalism. The enclosure **70** may be mounted to a mast or like support **42** which may also provide means for supporting the solar panel array **40**. Cables **58** may be provided to interconnect the warning signal device **12**, sensor probes **50**, and control unit **32**. These cables **58** may be buried in the earth adjacent to the tracks during installation of the warning system **10**. Conduits **72**, preferably made of steel or the like, may be provided to protect cable not buried.

FIG. **5** depicts a railroad crossing warning signal device **12** according to an exemplary embodiment of the present invention. The warning signal device **12** preferably comprises a standard X-shaped railroad crossing warning sign or "crossbuck" **18** mounted on a post or mast **20**. The surface of the cross-buck **18** preferably includes a plurality of reflectors, reflecting paint or the like for reflecting the lights of an automobile. A plurality of high intensity light emitting diodes ("LED") **22** or the like may be mounted across the center of the crossbuck **18** in an X-shape. These LEDs **22** may be animated, i.e. made to repeatedly flash on and off to attract the attention of motorists and enhance visibility of the sign at night or in poor weather conditions. Further, a shroud **74** may be mounted on the mast **20** behind the crossbuck **18** to improve the contrast between the crossbuck **18** and its background. Preferably, this shroud **74** is black. A strobe light/train direction advisory sign **24** may be mounted above the crossbuck **18** on the mast **20**. Like the crossbuck **18** this sign **24** may also have a black shroud **76** to improve the contrast between it and its background. The upper half of the sign **24** may comprise an array of strobe lights **26** which when activated function to alert the motorist of an approaching train. Preferably the array comprises four strobe lights which may have an intensity of approximately 4.5 million candlepower each. The strobe lights **26** are preferably red in color and may strobe or flash at a rate of approximately **440** flashes per minute to indicate to the motorist that he must stop. The lower half of the strobe light/train direction advisory sign **24** may comprise a train direction indicator **28** which provides a means of indicating to the motorist the direction the approaching train is traveling. The train direction indicator **28** may comprise a plurality of amber colored lamps **30** placed adjacent to each other so that they form a straight line. Upon detection of the presence of an approaching train by the system, these lamps **30** may be lighted sequentially to indicate the direction in which the train is traveling. For example, if a train is approaching the crossing from the left, the left-most lamp **30*a*** is lighted first, then extinguished. Immediately thereafter, the next lamp in line **30*b*** is lighted and extinguished, then the next **30*c***, and so on in quick succession until the right-most lamp **30*d*** is lighted then extinguished so that to a motorist viewing the sign **24**, a single light appears to move from left to right. This sequence is then repeated until the train clears the crossing and the warning signal device **12** is deactivated. If a train approaches the crossing from the right, the sequence is reversed so that it would appear to a motorist viewing the sign **24** that a single light moves from right to left. Embodiments of the warning signal device **12** may further include an audible warning means such as a siren horn or bell to provide an audible output signal (not shown).

FIG. **6** is a block diagram illustrating the interconnection of the various subsystems and components of the warning system. A sensor subsystem **80** may comprise a primary sensor probe array **82** and a backup sensor probe array **84** each including several magnetometer sensor probes and corresponding electronic circuitry to determine when a probe has detected the presence of a train. The sensor probes of the primary sensor probe array **82** are preferably arranged to form speed traps on either side of the grade crossing. Each speed trap may comprise two sensor probes placed at a predetermined distance from each other. The backup sensor probe array **84** may comprise two backup sensor probes placed on either side of the crossing between the crossing intersection and the innermost primary sensor probe. The sensor probes are preferably sealed assemblies which may be buried in earth for their useful life. Each sensor probe may be interconnected with electronic monitoring circuitry which produces a binary (on or off) signal when the presence of a train is detected by that probe. The primary sensor probe array **82** is monitored by electronic circuitry of the primary control subsystem **86** while the backup sensor probe array **84** is monitored by electronic circuitry of the backup control subsystem **88**. Both the primary and backup sensor probe array monitoring circuitry is preferably located in the control unit which may be housed an environmentally sealed equipment enclosure **70** (FIG. **4**) or vault **34** (FIG. **1**). The sensor subsystem **80** may comprise eight Cartel CT-6 magnetometer probe assemblies **50** (FIG. **4**) which terminate into five each CT-2N circuit board subassemblies (not shown). The CT-2B control board may be modified to include the addition of a voltage spike protection zener diode across its probe input connectors (not shown). This modification may substantially reduce the vulnerability of the assembly to damage should lightning strike the immediate vicinity of a sensor probe. The CT-6 probe construction features a sheath containing an epoxy encapsulated coil of wire terminated to a shielded cable.

Interconnecting cable **58** (FIG. **4**) may be provided between the sensor probes and the control unit. This cable may be a foam/skin insulated filled cable meeting REA Specification PE-89, such as CASPIC FSF manufactured by Essex Groups, Inc. of Decatur, Ill. The interconnecting cable may be buried in the earth and preferably features sheathing to provide protection against water penetration, and mechanical or rodent damage. The cable may also be shielded to reduce susceptibility to natural or manmade electromagnetic interference. Preferably, the cable is capable of supporting sensor probes located at distances of 2 or more miles from the associated control unit. However, the present invention would seldom require cable lengths longer than a half mile. (A speed trap located ½ mile from a grade crossing would allow 25 seconds of warning time for a train traveling at 72 miles per hour.) A cable monitoring or cable guard subsystem **100** (FIG. **6**) may monitor the integrity of a closed loop circuit in the buried cable. In the event that the cable is cut or damaged, the cable guard subsystem **100** preferably forces the warning system **10** into a fail safe condition **90** mode of operation resulting in illumination of the warning signal device's displays **92**, which include the crossbuck LEDs **22** (FIG. **5**), strobe lights **26** (FIG. **5**), and train direction indicator **28** (FIG. **5**) and audible warning means.

The control unit preferably comprises four additional subsystems: (1) the primary control subsystem **86**, (2) the backup control subsystem **88**, (3) the data recording or data logger subsystem **94**, and (4) the warning signal device control subsystem **96**. The primary control subsystem **86** may include the speed trap sensor probe monitoring circuits and a dedicated microprocessor assembly. This subsystem monitors the speed trap sensor probes and upon detection of an approaching train, determines parameters such as the train's speed, length, and the like in order to initiate activation of the warning signal device displays **92** located at the grade crossing. Preferably, the warning signal device displays **92** are activated at a predetermined time interval before the train reaches the crossing, regardless of the train speed. The primary control subsystem **86** may also initiate deactivation of the warning signal device displays **92** when the sensor probe arrays **82** & **84** and/or crossing guard subsystem **98** sense that the end of the train has passed the grade crossing. The primary control subsystem **86** may then reset the system in preparation for another train.

The backup control subsystem **88** preferably comprises a micro controller assembly which monitors the backup sensor probe array **84**. If not disabled by the primary control subsystem **86**, the backup control subsystem **88** may initiate activation of the warning signal device displays **92** whenever one or more of the backup sensor probes detects a train.

Preferably, this subsystem is automatically operational in the event of a failure of the primary control subsystem **86**.

The data recording or data logger subsystem **94** may comprise a micro controller subassembly including a microprocessor, date/time clock, and battery protected random access memory. This subsystem may monitor the primary control subsystem **86** and record various parameters including the speed and length of each passing train as well as the function of the system during each train passing. In addition, the data logger subsystem **94** may periodically perform diagnostic tests of the backup control subsystem **88** and backup sensor probe array **84**. If the backup subsystem **88** is found faulty, the data logger subsystem **94** may place the warning system **10** into the fail-safe condition **90** mode of operation. The microprocessor assembly (not shown) may include a lithium battery or the like to maintain the date/time clock and to maintain information stored in volatile memory.

The primary control subsystem and data logger micro controller assemblies may employ 8-bit microprocessors or the like. For example, the primary control subsystem **86** may utilize an RTC 31/52 computer board assembly, manufactured by Micromint Inc. of Vernon, Conn. Similarly, the data logger subsystem **94** may utilize a NanoLink micro controller board assembly, manufactured by Dison Technologies of Santa Barbara, Calif. Software may be employed to control the microprocessor's operation and to set operation variables. Thus, the warning system may be configured to meet the operational requirements of an individual site operational without modification to the system's hardware or physical installation.

The crossing guard subsystem **98** including the crossing guard transmitter **64** (FIGS. **3**A, **3**B) and receiver **66** (FIGS. **3**A, **3**B) may provide a signal to the control unit indicating the presence of a train in the crossing. The control unit may use this signal to continue activation of the warning signal displays **92** when a train has stopped in the crossing and thus would not otherwise be detected by the backup sensor probe array **84**. The control unit may utilize this signal to verify when a train has cleared the crossing.

The warning signal device control subsystem **96** may comprise relay logic circuits switched on and off by the control unit's subsystems to provide fail safe operation of the warning signal device displays **92**. All relays in the subsystem are preferably maintained in the actuated (contacts open) state at all times. All relays are preferably industrial quality electro mechanical or solid state relays.

A power supply subsystem **102** may be provided comprising one or more rechargeable batteries and recharging circuitry. This recharging circuitry may operate using conventional 120/240 VAC electrical power from a public utility or other external source. In more remote areas, a solar panel array may provide electrical power to recharge the batteries so that the system may be operated independently from outside power sources. The power supply's batteries and recharging circuitry may be mounted in the same waterproof underground equipment vault which houses the control unit.

The railroad crossing warning system **10** may provide redundant means to activate the warning device displays **92** located at the railroad grade crossing. The system preferably comprises two basic layers of protection: (1) the control subsystems and (2) the fail safe condition. The control subsystems may include two separate subsystems having electronic circuitry used to control the warning signal device displays **92**: the primary control subsystem **86** and its associated primary sensor probe array **82**, and the backup control subsystem **88** and its associated backup sensor probe array **84**. The primary control subsystem **86** monitors the primary sensor probe array's speed traps and activates the warning signal device displays **92** whenever a sensed event (i.e. the detection of a train) is deemed a normal train passing event (i.e. the train passes through a speed trap within a defined time window). If the sensed event does not fall within "normal" train passing event criteria, control of system preferably reverts to the backup control subsystem **88**. If the sensed event falls within "normal" train passing event criteria, the primary control subsystem **86** may disable the backup control subsystem **88** and take control of the system. During the time that the backup control subsystem **88** is disabled, the primary control subsystem **86** may analyze the backup control subsystem **88** for proper operation. If the backup control subsystem **88** is found faulty, the primary control subsystem **86** may place the entire warning system into the fail safe mode of operation. Conversely, the purpose of the backup control subsystem **88** is to activate the warning signal device displays **92** in the event that the primary control subsystem **86** is unable to do so. Thus, redundancy is achieved by virtue of the backup subsystem's capability to protect a grade crossing should the primary control subsystem fail. Additionally, the backup control subsystem **88** may offer protection whenever unusual events (i.e. events which do not fall within "normal" train passing event criteria) are in process. Examples of unusual events include:

1. A short train passes slowly through a primary sensor probe array **82** speed trap and stops. When the train again moves, it may be detected by the backup sensor array **84** allowing the backup control subsystem **88** to activate the warning signal device displays **92**.
2. A train comes to a stop while spanning the crossing. The crossing guard subsystem **98** may continue activation of the warning signal device displays **92**. When the train again moves, the backup control subsystem **88** may continue activation of the warning signal device displays **92** since the primary sensor probe array **82** would not have detected the train.
3. A high railer passes through a primary sensor array speed trap in the reverse direction (i.e. it is detected by the innermost sensor probe before being detected by the outermost sensor probe). When the outermost sensor probe detects the high railer, the primary control subsystem's micro controller is alerted that an event may be in progress. The micro controller finds that the innermost sensor probe has already detected the train. Since the micro controller may require about 0.32 seconds to become fully active after being alerted that the outermost sensor probe is tripped, it determines that something has passed through the speed trap in about 0.32 seconds (in excess of 200 mph), rejects the event as being outside normal train passing event criteria, and does not disarm the backup control subsystem **88**.

The second level of redundancy is provided by the fail safe condition **90**. The fail safe condition **90** is the condition where a vital relay is no longer energized. Upon loss of power to the vital relay the relay contacts may close thus providing power to the warning signal device displays **92**. The warning signal device displays **92** may remain illuminated until maintenance is performed on the system and the control unit circuitry is manually reset. The fail safe condition mode of operation is the final level of redundancy regarding protection of the grade crossing. The fail-safe condition may be achieved by maintaining a display relay in a contacts-open position whenever the warning signal device displays **92** are not to be illuminated. In the event of a failure of the control unit circuitry the vital relay would be de-energized and would revert to it's normally closed state. Closure of the relay connects the warning signal device displays **92** directly to battery power and the displays remain illuminated until the fault is repaired and the system is reset by maintenance personnel.

FIGS. **7** and **8** depict alternative embodiments of the present invention wherein the warning signal device may be modified for use at grade crossings experiencing a high volume of automobile traffic. As shown in FIG. **7**, the warning signal device **12** may comprise a standard crossing gate **110** to prevent motorists from entering the grade crossing when an approaching train is detected. Upon detection of an approaching train and activation of the warning signal device by the system, a cantilevered arm **112** may be lowered across the roadway at the entrance to the crossing to block automobiles from entering the crossing. After the train has cleared the crossing, the arm **112** may be raised to allow traffic to pass through the crossing. The gate **110** be mounted directly to the mast **20** of the warning signal device **12** or may itself be free standing. A plurality of lights such as LEDs **114** may be mounted along the center of the arm **112**. These LEDs **114** improve the motorists ability to see the closed gate at night or in poor weather. Although a standard railroad crossing gate **110** is shown, the present invention anticipates the use of four quadrant gates and the like. FIG. **8** illustrates an alternative arrangement of the warning signs. A cantilever support structure **120** may have a cantilevered arm, truss assembly, or the like **122** which may extend over a multilane roadway. One or more animated crossbucks **18** may be mounted on this structure as required to adequately warn motorists in all lanes of traffic. Likewise, multiple strobe light/train directional indicator signs **24** may be mounted on the cantilevered arm **122** of the support structure **120** to warn the motorists in all lanes of traffic.

FIG. **9** illustrates the use of the present invention in a crossing **128** having multiple railroad tracks such as in an industrial area or near a freight yard. Sensor probes **50** may be placed at various positions on along of the tracks **130** to detect the presence of oncoming trains **132**. Preferably the sensor probes **50** are buried in the right of way along the outermost train rails **134** and are capable of detecting a train moving along any of the tracks **130**.

In view of the above detailed description of a preferred embodiment and modifications thereof, various other modifications will now become apparent to those skilled in the art. The claims below encompass the disclosed embodiments and all reasonable modifications and variations without departing from the spirit and scope of the invention.

What is claimed is:

1. A railroad crossing traffic warning system for alerting a motorist approaching a railroad crossing to the presence of an oncoming train, said warning system comprising:

a sensor positioned adjacent to the railroad track at a predetermined distance from the railroad crossing, said sensor for detecting an oncoming train and for producing a signal in response thereto;

an alerting device for alerting the motorist to the presence of an oncoming railroad train such that the motorist may take cautionary or evasive action before the arrival of the train at the railroad crossing; and

a controller operatively coupled to said sensor and said alerting device, said controller for receiving the signal from said sensor and controlling operation of said alerting device in response thereto, said controller further comprising:

a processor for processing the signal received from said sensor and controlling said alerting device in response to said processed signal;

a sensor signal interface for interfacing said processor with said sensor to provide the signal received from said sensor to said processor; and

an alerting device interface for interfacing said processor with said alerting device.

2. The railroad crossing traffic warning system of claim **1**, wherein said sensor comprises a magnetometer.

3. The railroad crossing traffic warning system of claim **1**, wherein said controller comprises a rechargeable battery.

4. The railroad crossing traffic warning system of claim **3**, further comprising a solar panel array for charging said rechargeable battery.

5. The railroad crossing traffic warning system of claim **1**, wherein said alerting device comprises:

a support placed at an entrance to the railroad crossing; and

a visual warning assembly mounted on said support means for providing a visual output signal, said visual warning assembly being responsive to said controller.

6. The railroad crossing traffic warning system of claim **5**, wherein said visual warning assembly comprises an X-shaped railroad crossing warning sign, said warning sign having a reflector for reflecting the lights of an oncoming automobile and a plurality of lighting devices forming an X-shape.

7. The railroad crossing traffic warning system of claim **6**, wherein said lighting device comprises a light emitting diode.

8. The railroad crossing traffic warning system of claim **5**, wherein said visual warning assembly comprises a strobe light.

9. The railroad crossing traffic warning system of claim **5**, wherein said visual warning assembly comprises a train direction indicator, said train direction indicator including a plurality of lamps arranged adjacent to each other in a line wherein said lamps may be lighted sequentially to indicate the direction in which an oncoming train is traveling.

10. The railroad crossing traffic warning system of claim **1**, wherein said alerting device comprises audible warning device.

11. The railroad crossing traffic warning system of claim **10**, wherein said audible warning device comprises a siren horn.

12. The railroad crossing traffic warning system of claim **10**, wherein said audible warning device comprises a bell.

13. The railroad crossing traffic warning system of claim **1**, wherein said processor is a microprocessor.

14. The railroad crossing traffic warning system of claim **1**, wherein said processor further performs diagnostics to monitor operation of the system for proper function.

15. A railroad crossing traffic warning system for alerting a motorist approaching a railroad crossing to the presence of an oncoming train, said warning system comprising:

means for detecting an oncoming train and producing a signal in response thereto;

means for alerting the motorist to the presence of an oncoming train so that the motorist may take cautionary or evasive action before the arrival of the rain at the railroad crossing; and

means for receiving the signal from said detecting means and controlling said alerting means in response thereto, said controlling means further comprising:

means for processing the signal received from said sensor, controlling said alerting device in response to said processed signal and monitoring operation of the system for proper function;

means for interfacing said processing means with said sensor to provide the signal received from said detecting means to said processing means;

means for interfacing said processing means with said alerting means.

16. The railroad crossing traffic warning system of claim **15**, wherein said detecting means comprises a magnetometer.

17. The railroad crossing traffic warning system of claim **15**, further comprises means for supplying power to the system.

18. The railroad crossing traffic warning system of claim **15**, wherein said alerting means comprises:

means for providing a visual warning to a motorist; and

means, placed at an entrance to the railroad crossing, for supporting said visual warning providing means.

19. The railroad crossing traffic warning system of claim **18**, wherein said alerting means further comprises means for indicating the direction in which the oncoming train is traveling.

20. The railroad crossing traffic warning system of claim **15**, wherein said alerting means comprises means for providing an audible warning.

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